Is more activity always better?
A department-wide study of relationships between classroom practices and student performance

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And thanks to Trish Schulte, Martha Mullally, Erica Jeffery, and Garrett Huwyler

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Inspired by last year at SABER...

Scott Freeman et al, PNAS 2014:

“Active learning increases student performance in science, engineering, and mathematics”

Travis Lund et al, CBE-LSE 2015:

Using COPUS to capture department-wide instructional practices.
Next Generation Research Questions...

- Do different active learning techniques contribute more to student learning than others?
- Is more always better?

Our operationalized variables (what we measured):

- Performance on a diagnostic test
- Specific teaching approaches
- COPUS data about specific classroom practices
- Student learning
## Scope and Tools

### COPUS observations

- 33 lecture sections in 17 biology classes
- For each, observed “a typical week” (~3 hours)

<table>
<thead>
<tr>
<th>Course Year</th>
<th># Course Sections</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
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<td>4</td>
<td>6</td>
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</tbody>
</table>

### Diagnostic tests

- One test per course; developed with instructor
- ~10-15 multiple choice concept questions
- 217 questions total, compiled from validated inventories or developed with instructors
- Over 6500 (non-unique) students tested
Instructional styles & learning gains

Normalized change for a given student (from Marx & Cummings 2007):
For increases: \( \frac{(\text{Post} - \text{Pre})}{(100 - \text{Pre})} \)
For decreases: \( \frac{(\text{Post} - \text{Pre})}{\text{Pre}} \)

* \( p<0.05 \)
Peer discussion using clickers

82% of our classes spend at least some time on peer discussion with clickers.

Here, more is better... to a point.

F_{1,32} = 5.51, r^2 = 0.27, p = 0.03
Impact of the presence/absence of a given activity

<table>
<thead>
<tr>
<th>Class level</th>
<th># sections</th>
<th>Section size</th>
<th>% sections using groupwork</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years 1&amp;2</td>
<td>22</td>
<td>242 +/- 48</td>
<td>100%</td>
</tr>
</tbody>
</table>

100% using clickers
41% using worksheets
91% using ‘other groupwork’

Using the 1st/2nd year data:
Use of worksheets, in particular, supports student learning

![Graph showing mean normalized learning change (%) with error bars.](image)

Worksheets were used in observed lectures
Worksheets were not used in observed lectures

* p<0.05
For worksheets, is more time-on-task better?

A trend, but the fit is not significant.

How to account for the variability between sections?

Diagram:
- X-axis: Average % class time - students doing worksheets in groups
- Y-axis: Average normalized change on diagnostic test
- Size of data point indicates relative size of class section.
For worksheets, is more time-on-task better?

A trend, but the fit is not significant.

How to account for the variability between sections?

Can we rule out worksheet ‘quality’?

Two different sections using the same worksheet

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For worksheets, is more time-on-task better?

- Clickers
- Our dept has spent time on these – easily implemented and good to do.

Worksheets

Average normalized change on diagnostic test

Average % class time - students doing **worksheets in groups**

Size of data point indicates relative size of class section.
Class time, choreography, and concurrent activities

Raw COPUS data of each class:
Conclusions & Next Steps

Instructional style has a big impact on student learning!

Clickers (at least for us) are a valuable use of class time
  • Even trying clicker peer discussion in a small way is beneficial
  • Choreography has been well-developed/supported

Worksheets: promising, but:
  • Good potential for structured work and feedback
  • We need to think carefully about worksheet choreography within the class, and other factors

More active is generally better... but the data doesn’t account for all of the variability:
  • Current data is not yet a strong predictor
  • Need stronger analyses of COPUS, and need other tools!
<table>
<thead>
<tr>
<th>Validated concept questions - topic</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biomechanics</td>
<td>Knudsen et al., 2003</td>
</tr>
<tr>
<td>Genetics</td>
<td>Smith et al., 2008</td>
</tr>
<tr>
<td>Osmosis</td>
<td>Fisher et al., 2011</td>
</tr>
<tr>
<td>Meiosis</td>
<td>Kalas et al., 2013</td>
</tr>
<tr>
<td>Molecular Biology</td>
<td>Couch et al., 2014</td>
</tr>
<tr>
<td>Phylogenetic trees</td>
<td>Baum et al., 2010</td>
</tr>
<tr>
<td>Genetic drift</td>
<td>Price et al., 2013</td>
</tr>
<tr>
<td>Dominance</td>
<td>Abraham et al., 2014</td>
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<tr>
<td>Biochemistry</td>
<td>Villafane et al., 2011</td>
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<tr>
<td>Population Dynamics</td>
<td>Hansen et al.</td>
</tr>
<tr>
<td>Biological Experimental Design</td>
<td>Deane et al., 2014</td>
</tr>
<tr>
<td>Transcription and Translation</td>
<td>Taylor et al.</td>
</tr>
<tr>
<td>Carbon cycling</td>
<td>Cordero Maskiewicz et al., 2012</td>
</tr>
<tr>
<td>Molecular/Cell Biology</td>
<td>Shi et al., 2010</td>
</tr>
<tr>
<td>Intro Biology</td>
<td>Klymkowsky et al., 2010</td>
</tr>
<tr>
<td>Photosynthesis</td>
<td>Parker et al, 2012</td>
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<tr>
<td>Enzyme-substrate interactions</td>
<td>Linenberger and Bretz, 2012</td>
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Thank you!